



# Facility for Payload Cleaning and Assembly and for Curation of Returned Genesis Solar Wind Samples

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# THE BIG PICTURE



- **JSC Curation Supported Genesis Mission from Beginning to End**
- **Transitioned to Long Term Curation and Providing Samples for Researchers**

## Mission & Science Team Support

- Early Sample Hardware Requirements & Inputs
- Advocate for the Scientific Integrity of the Collected Samples
- Coordination with ALL Mission Partners
- Contingency Planning for Surface Operations to Science Sample Recovery on Earth (Genesis Mission Contingency Plan Heritage)
- Science Payload Recovery Operations

## Flight Hardware Cleaning

- Procedure Development for Precision Cleaning
- ISO Class 4 Precision Cleaning Laboratory
- Precision Cleaning for Flight Hardware & Assembly Tools
- Cleaning Verification and Analysis

## Flight Hardware Clean Assembly

- ISO Class 4 Assembly Cleanroom Lab
- Precision Cleaned Assembly Tools & Specialized Tooling
- Hardware Testing in Clean Environment
- Final Hardware Close-Out and Sealing for Flight
- Genesis Science Canister Assembly & Sealing Heritage

## Flight Hardware Design Support

- Material Selection to Reduce Contamination
- Hardware Geometry Selection to Ensure Cleanability for Reducing Contamination
- Containment and Seals Selection for Long-Term Preservation
- Ensure Science Goals & Requirements are Met
- End-to-End Sample Containment Strategy for Contamination Control:  
*Hardware Cleaning & Assembly – Sample Acquisition – Containment & Seals – Long-term Storage – Earth Opening/Extraction*

**Curation facilities  
play an  
important role in  
all of these  
functions!**

## Archival & Documentation

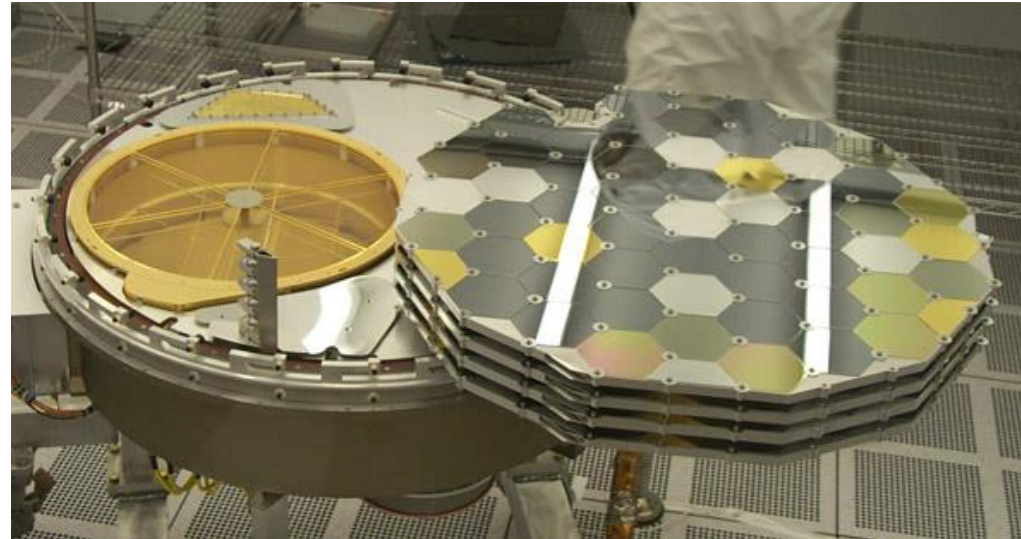
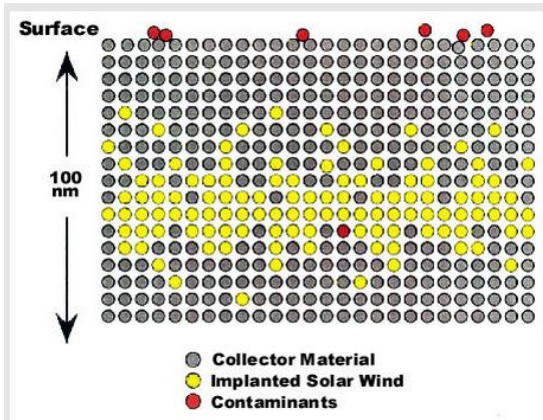
- Material Reference Coupon/Witness Plate Archival from Precision Cleaning Through Assembly & Sealing for Flight
  - Environmental (structure, maintenance, airborne samples)
  - Cleaning process reference material
  - Payload material reference coupons
- Documentation & Contamination Control Plan – Procedures, Transport/Track & Database Development
- Testing, Analysis & Archival for Future
- Well-established Preflight and Flown Hardware Archive Facilities in ISO class 4 to 7 cleanrooms
- Proven Long-term Storage in Inert Glovebox & Desiccator Environments

# FACILITY FOCUS: Purpose

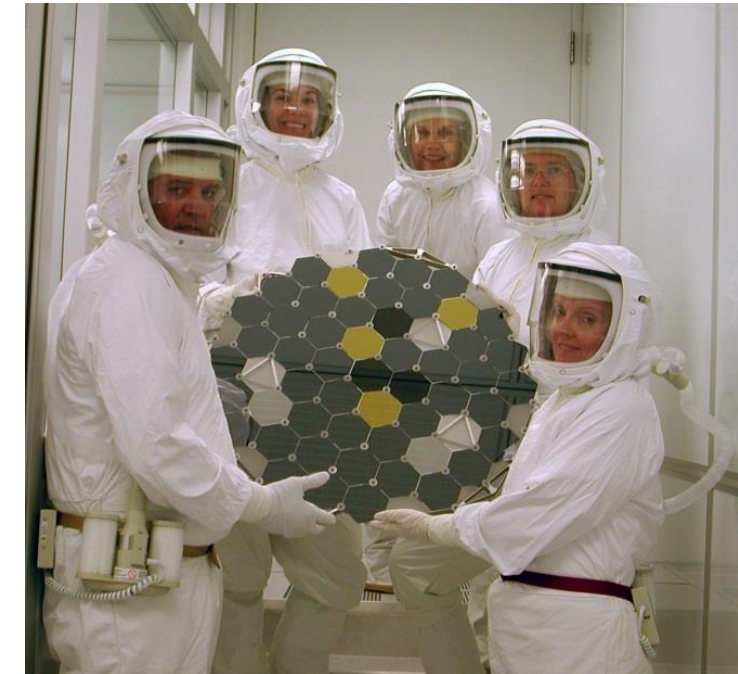


## RETURN SAMPLES CONTAINING CAPTURED SOLAR WIND ATOMS FOR LABORATORY MEASUREMENT

- Collector Materials are “containers” which will capture and hold solar wind



- Must be pure enough
  - Solar wind fluence is low
  - Design goal is signal to noise ratio  $>100$ , critical requirement  $SNR >10$
- Must be clean enough
  - Surface contamination  $< 2$  year SW fluence for any element
  - If some surface contamination does occur, there must be methods for removing it

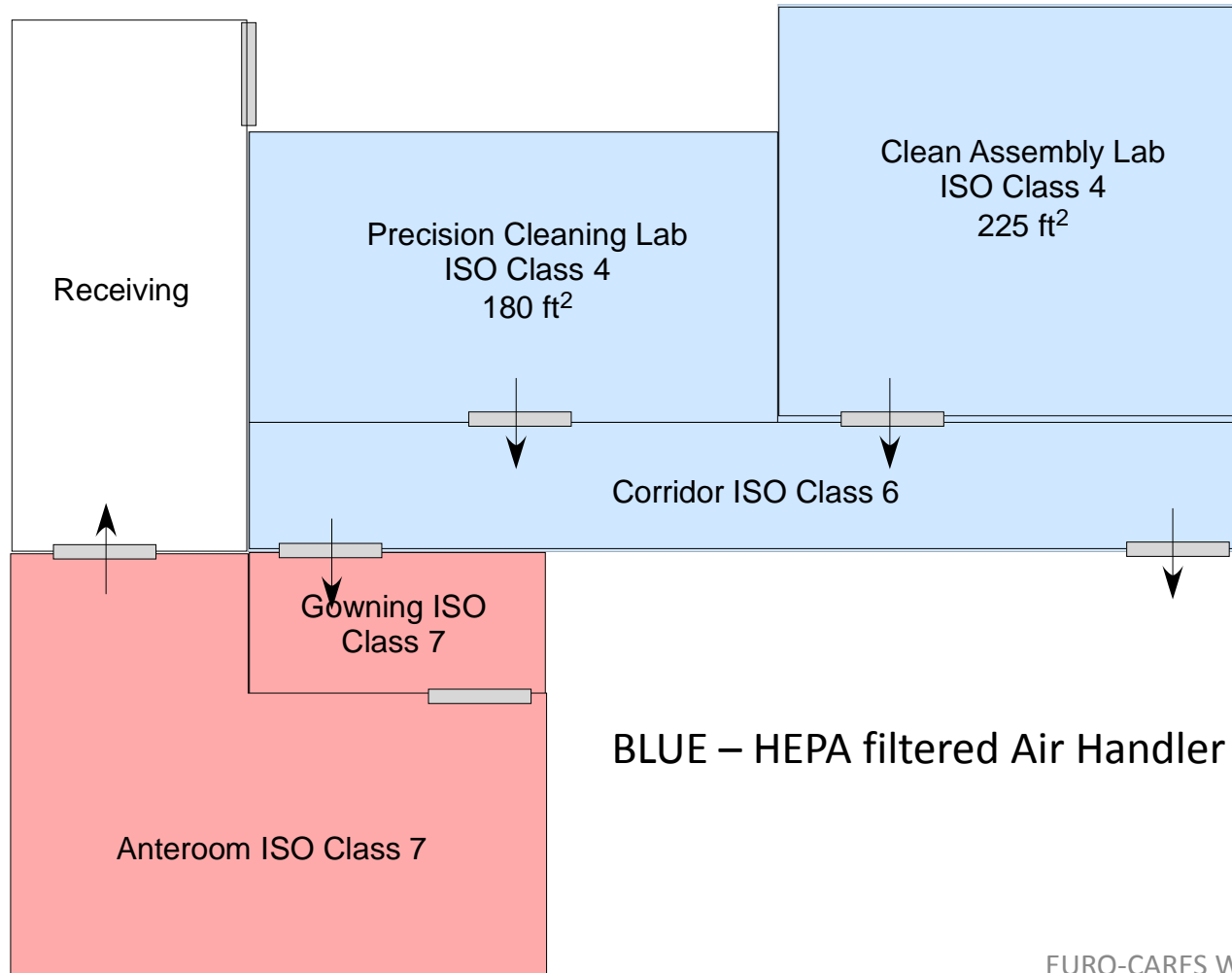




# FACILITY FOCUS: Overview of a retrofit laboratory



AIR HANDLERS ARE CRITICAL FOR MAINTAINING DIFFERENTIAL ROOM PRESSURES



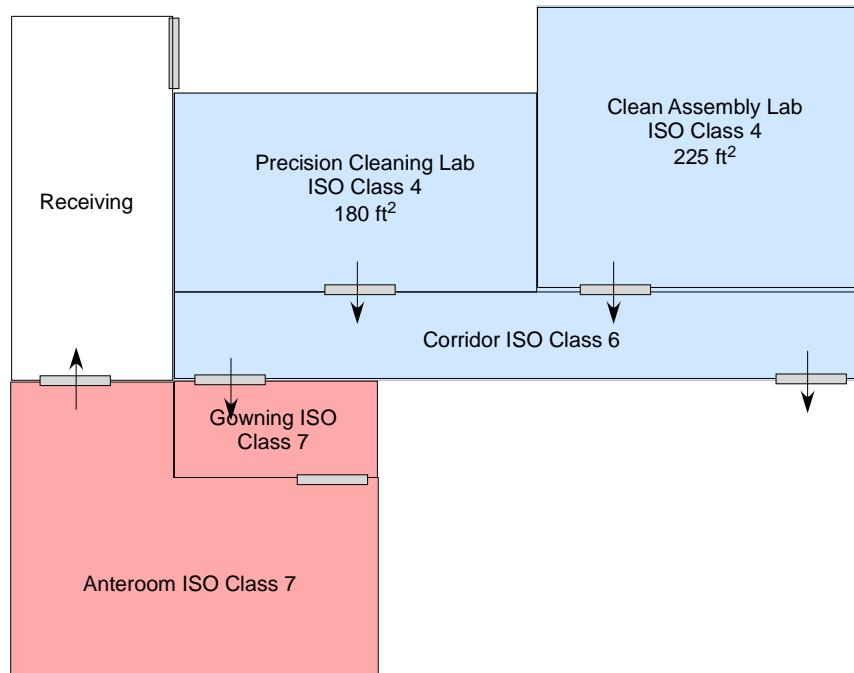
## Facility Capabilities

- ✦ Two ISO Class 4 Positive Pressure Cleanrooms
- ✦ Maintained to ISO 14644 Specifications
- ✦ ULPA Fan Filter Unit Air Filtration
- ✦ Laminar Air Flow from Ceiling to Floor
- ✦ Raised Floor Air Recirculation
- ✦ Facility is currently used by Genesis Curation

## List of Current Equipment

- ✦ Ultrapure Water (UPW) System: E-1 Grade or better (ASTM D5127-13) & UPW Heater
- ✦ Gaseous Nitrogen System: Boil-off grade C LN<sub>2</sub> (MIL-PRF-27401G) & GN<sub>2</sub> Heater
- ✦ GN<sub>2</sub> storage desiccators
- ✦ 72 kHz Ultrasonic UPW Cascade Tank and Baths
- ✦ 1 MHz Megasonic Pulse UPW Cleaning
- ✦ Liquid Particle Counters (> 1 μm)
- ✦ Optical Automated Scanning Microscopes
- ✦ Stereomicroscopes
- ✦ FT-IR with Continuum Microscope
- ✦ UV-Ozone Cleaner
- ✦ Clean tools for handling and assembly

# FACILITY FOCUS: ISO Class 4, a drop-in room



SHOWN IN BLUE

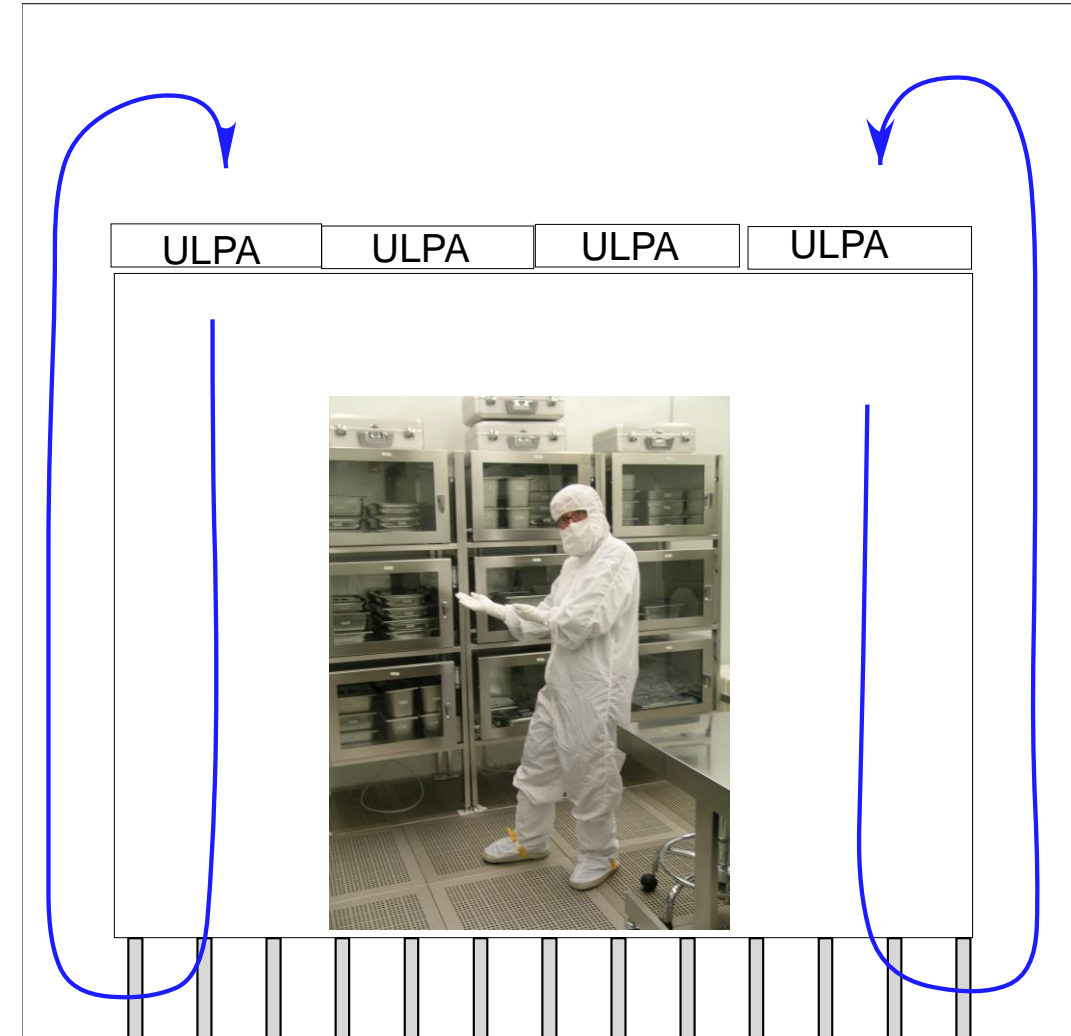
Vertical laminar flow

100 fpm ULPA ( $<0.12 \mu$ )

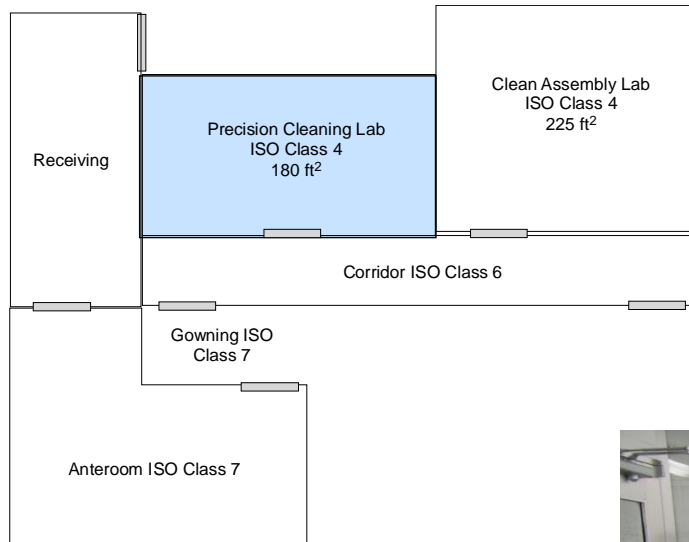
Fed by HEPA air handler ( $<0.3 \mu$ )

Total ULPA coverage ceiling

Total floor air flow holes



# FACILITY FOCUS: ISO Class 4 Ultrapure water precision cleaning



Ultrasonic cascade bath

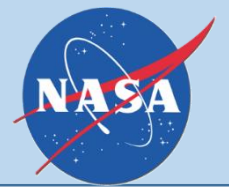


Megasonic spin cleaner





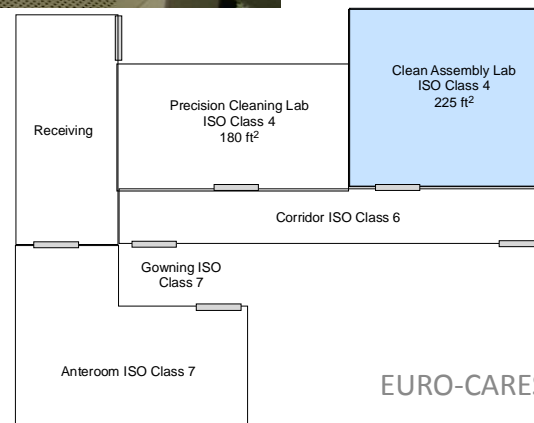
# FACILITY FOCUS: ISO Class 4 sample characterization & nitrogen storage



Nitrogen purge sample storage



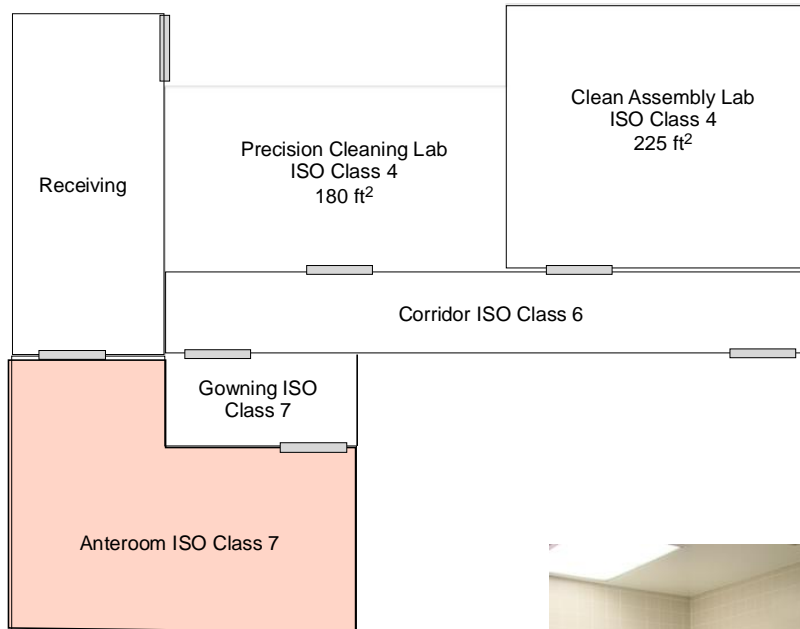
Microscope, FT-IR,  
ellipsometer,  
scanning optical  
microscope



13 April 2016

EURO-CARES WP3

# FACILITY FOCUS: ISO Class 7 entry room



HEPA filtered storage cabinet, flow bench





# FACILITY FOCUS: construction, subfloor



Incipient Fire Detection  
UPW  
Nitrogen gas

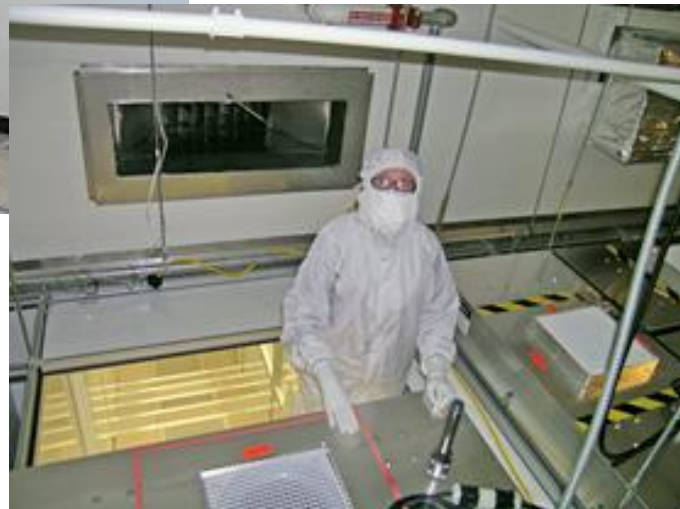




# FACILITY FOCUS: Construction, hanging the ULPA filter units



Above the ULPA  
Fan Filter Units



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O-CARES WP3

# FACILITY FOCUS: Remote sample storage



- Store a subset of the collection at a remote location
- Static nitrogen storage

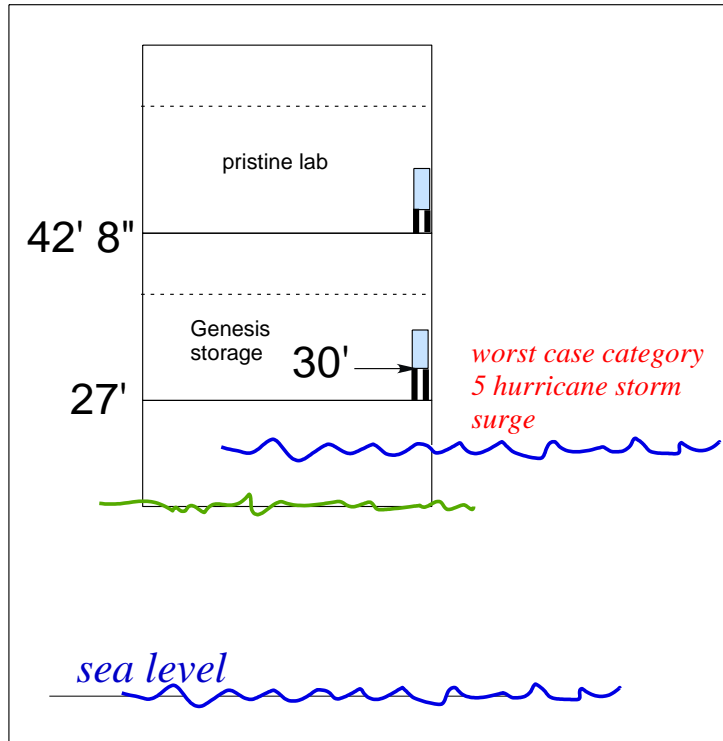


15 April 2016

LEGO-CARES WFS



# FACILITY FOCUS: Hurricane readiness storage

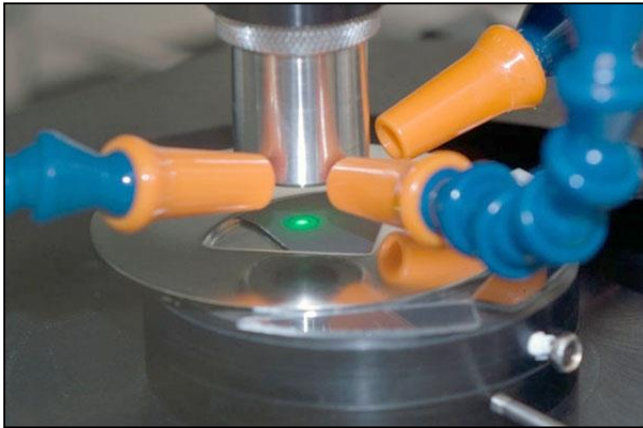


Samples not currently being worked are stored in upstairs vault during hurricane season. Kept in rolling desiccators purged with nitrogen. Moving process practiced annually.

# FACILITY FOCUS: Separate laser scribing subdivision



Laser scriber for subdividing large samples. Set up inside laminar flow clean tent.





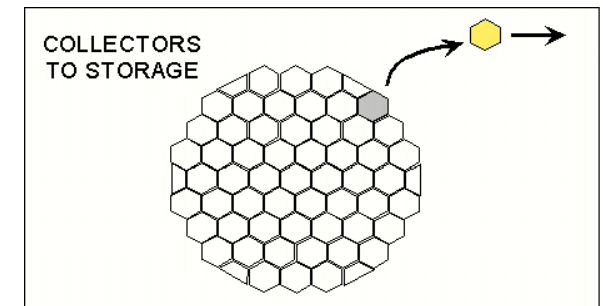
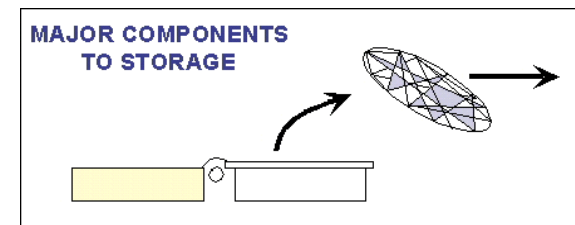
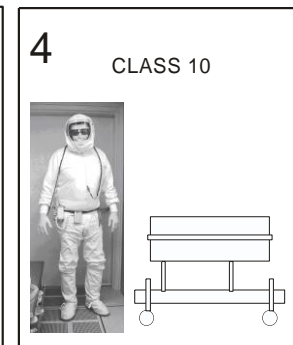
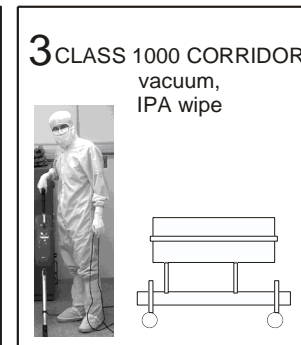
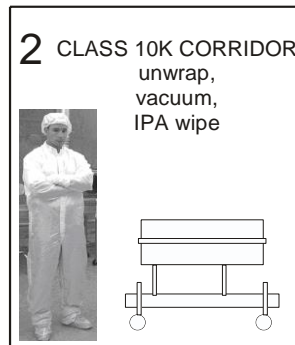
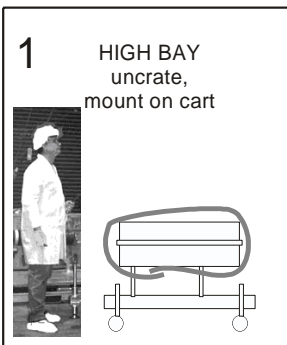
# FACILITY FOCUS: Sample receiving as planned



- Set-up cleanroom in hangar at UTTR
- Put nitrogen purge on science canister
- Ship to JSC

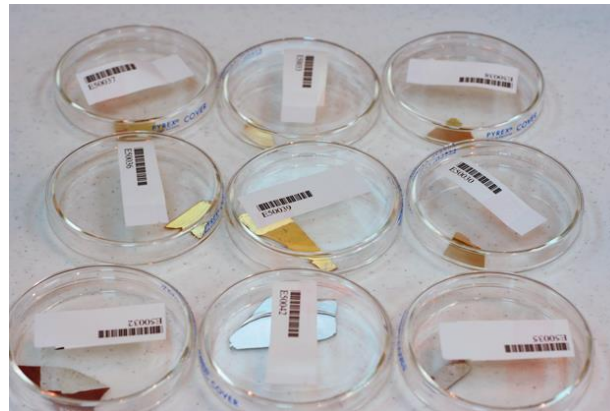


Arrival at JSC





# FACILITY FOCUS: Sample recovery as happened



UTTR dilution cleanroom was used! More than 10,000 collector fragments were imaged and packaged in less than one month.

Contingency supplies already in place included 1000's of prenumbered containers.



# FACILITY FOCUS: Initial receiving at JSC



JSC ISO Class 4  
Nitrogen storage,  
room air handling



# EXAMPLES: Things we did right and lessons learned



## PAYLOAD CLEANING AND ASSEMBLY

- Clean assembly wearing HEPA filtered suits
- Minimization of organic material inside the payload
- Cleaning with ultrapure water (UPW) using ultrasonic & megasonic energy
- Bare aluminum is not easily cleaned without alteration (oxide formation)
- Airborne particle and UPW monitoring

## DURING RECOVERY OPERATIONS IN UTAH

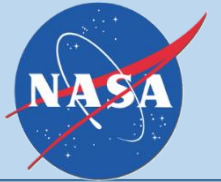
- Assets were in place to handle worse case scenario (hard landing)

## CURATION OF RETURNED SAMPLES

- Competing air handlers
- Ability to clean solar wind sample substrates using megasonic UPW



# EXAMPLE, did right: Clean Payload Assembly & Function Testing



- ISO Class 4, personnel wearing fully enclosed suits with HEPA filters
- Strict protocols, JPL QA: example – fasteners not touched by gloved hands, installed using tweezers
- Cultural differences - team worked well together

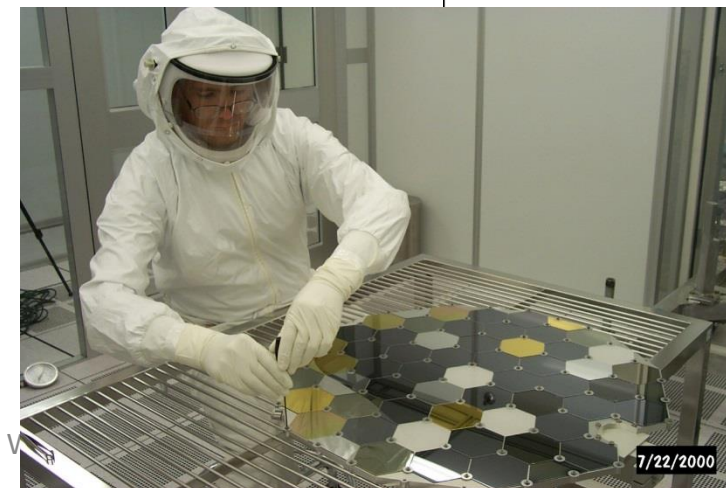


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EURO-CARES V



*During assembly, fasteners were handled with tweezers, not gloved fingers.*



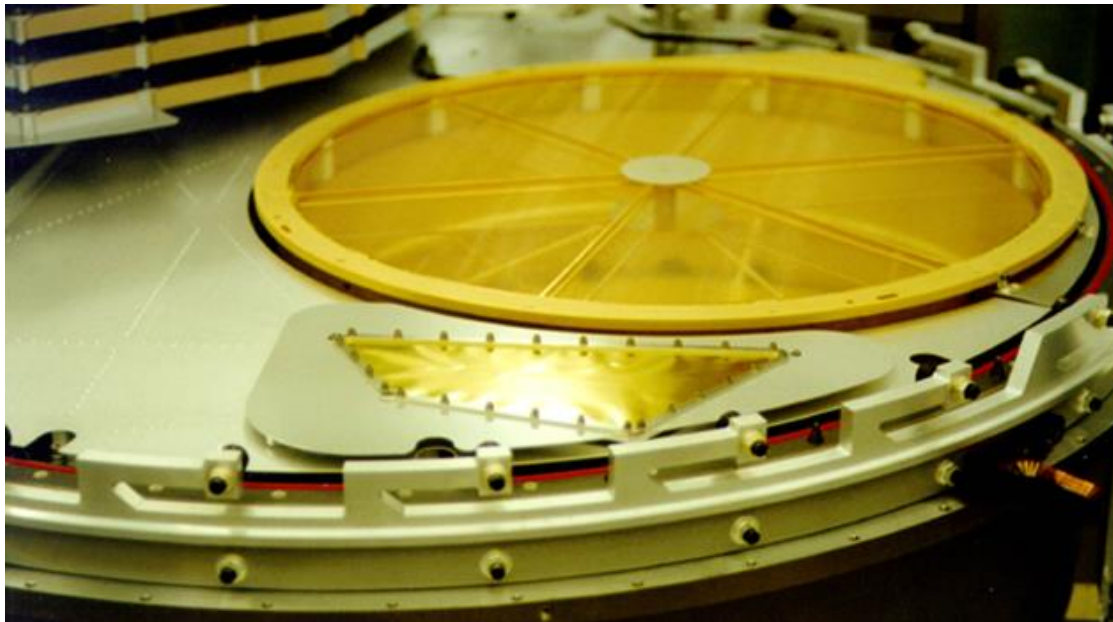


- ISO Class 4 for cleaning and assembly
- New cleaning techniques – megasonic energized UPW
- Verification methods: particle count rinse water, optical inspection, witness coupon measurement (XPS) to validate process
- Measurement of airborne molecular contamination (semi-annually), particle counts (weekly)
- Continual monitoring of UPW quality: resistivity 18.2 M $\Omega$ , TOC ,5 ppb. UPW chemical & biological analyses (semi-annually or as needed). Ion concentration low parts/trillion
- Material and personnel access controlled

# EXAMPLE, did right, but could have been better: Minimize organics

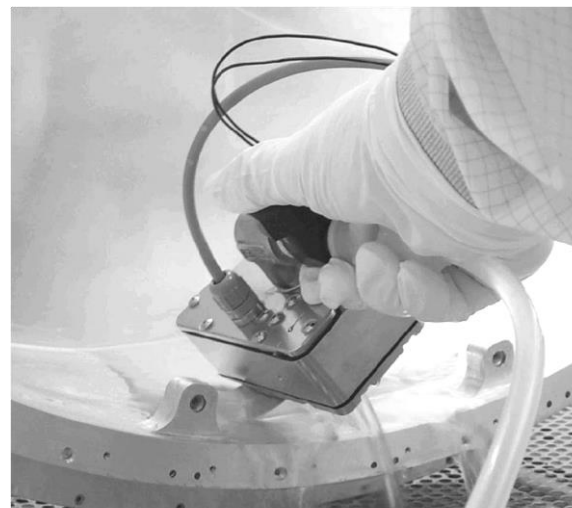
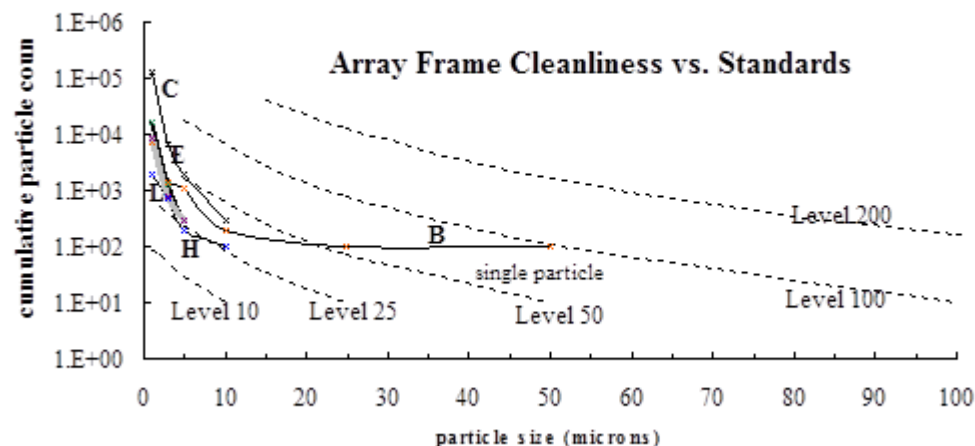


- Tight control of amounts applied – tiny amounts RTV applied with dental pick, Braycote applied with 2-mm brush
- Mechanism lubricants isolated to vent to outside of canister
- “Brown stain” polymerized RTV-like material, 50A thick





# EXAMPLE, did right: High level cleanliness using UPW



**Fig. 4-10.** A stream of megasonically energized UPW generated by a portable wand is used to clean the canister base.



**Fig. 4-9.** Canister base is rinsed with ultrapure water (UPW)



Megasonic energy  
on UPW head

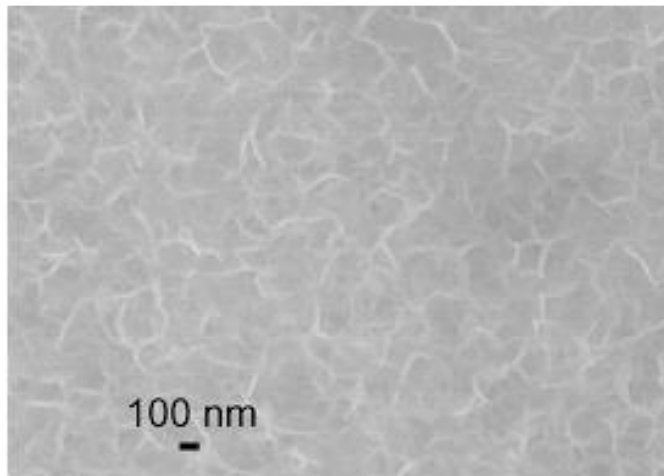
Ultrasonic energy in  
bath



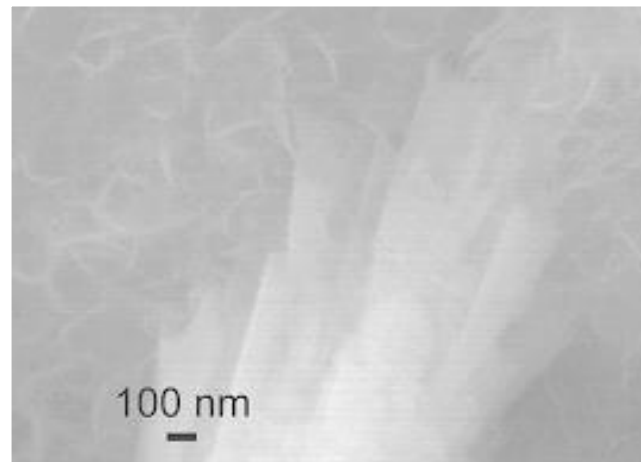
# EXAMPLE, lesson learned: Cleaning bare aluminum results in oxide formation



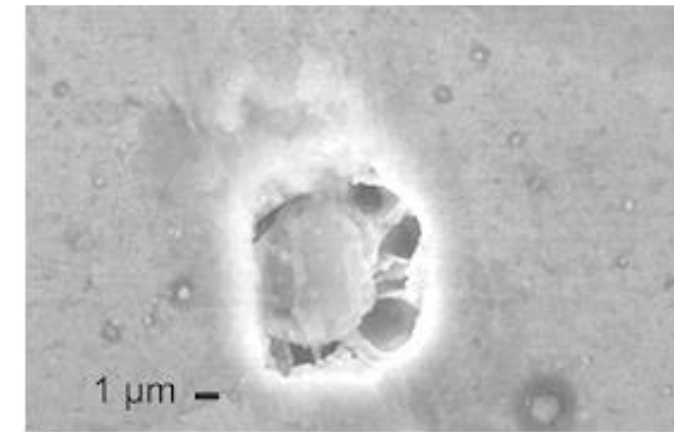
Has implications for difficulty of CLEAN and STERILE for aluminum spacecraft parts



*The wrinkled texture of hydroxides (boehmite?) resulting from UPW cleaning of aluminum 6061 at 75°C for 30 min. Scale bar is 100 nm.*



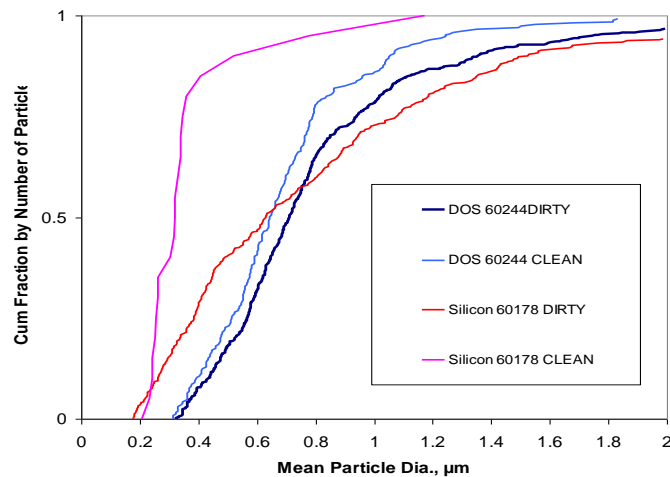
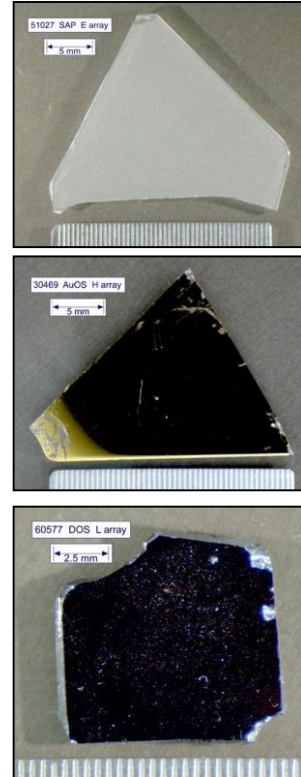
*The needle laths (bayerite?) radiating from single point. The view is from same coupon in fig. 4-5. Scale bar is 100nm.*

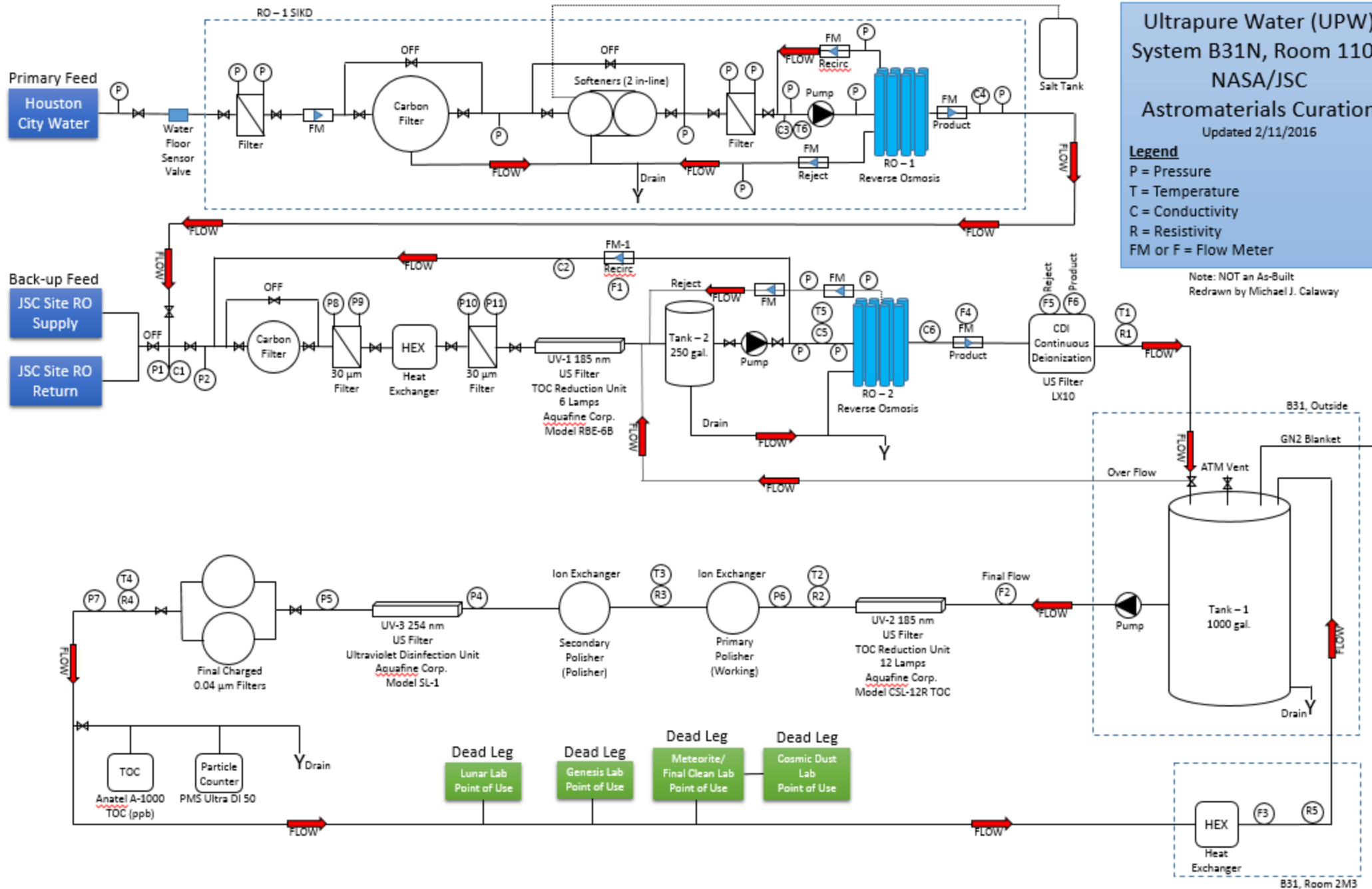


*Erosion pit around inclusion in aluminum 6061 cleaned in UPW at 50°C for 30 minutes. Scale bar is 1 µm.*



# EXAMPLE, did right: Developed technique for cleaning SW sample substrates with UPW







# THE BIG PICTURE: facility going forward.....



- **JSC Curation Supported Genesis Mission from Beginning to End**
- **Transitioned to Long Term Curation and Providing Samples for Researchers**

- Secure, storage under nitrogen cover gas
- Regular monitoring of airborne particulates, UPW chemistry
- Sample characterization in ISO Class 4 room using microscopes and analytical instruments
- Cleaning of sample substrates with UPW
- Maintenance of extensive reference material collection
- Providing researchers with appropriate solar wind samples and reference materials

Genesis Lab was a 1998 retrofit laboratory inside of the 1978 lunar sample building. A new, long-term facility plan needs core utilities better located for easy maintenance and upgrade. A receiving facility, for samples requiring strict containment, also needs laboratory instruments located for easy maintenance and upgrade.